



Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE
JOURNAL OF GEOLOGY

MAY-JUNE 1920

THE CHESTER SERIES IN ILLINOIS¹

STUART WELLER
University of Chicago

PART I

The Mississippian rocks in Illinois occupy three distinct areas along the western and southern borders of the state. The northernmost of these areas is the larger, and extends from southern Mercer County on the north to northern Madison County on the south. Throughout this entire distance, except for an interval in Pike, Calhoun, and Jersey counties, where older rocks are exposed, the rock formations of the Mississippian system constitute the Mississippi River bluffs. This area also includes the Mississippian strata which are exposed in the valley of the Illinois River as far north as Scott, Brown, and Schuyler counties. Nowhere in this area do the higher formations of the system occur, the youngest formation exposed being the Ste. Genevieve limestone, in the summit of the bluffs above Alton.

The second of the three areas occupies portions of St. Clair, Monroe, Randolph, and Jackson counties. This area includes about 85 miles of the Mississippi River bluffs from a short distance below East St. Louis to the gap formed by the valley of the Big Muddy River, and at only one locality in this entire distance, at

¹ Published by permission of the Directors of the Geological Surveys of Illinois and Missouri.

Valmeyer in Monroe County, are any formations other than the Mississippian exposed. The greatest width of this area is in Monroe County, where the Mississippian formations form the surface rocks for a distance of about fifteen miles back from the river bluffs, where they pass beneath the Pennsylvanian strata. Within this area both the lower and upper series of Mississippian formations are present, and it includes the typical area of the Chester series, as these rocks were described by Hall and Worthen more than half a century ago.

The third area of Mississippian rocks in Illinois is in the extreme southern portion of the state, where these formations constitute the surface rocks throughout a belt ranging from fifteen to thirty or more miles in width, across Union, Johnson, Pope, and Hardin counties. The greater portion of this area is occupied by the upper Mississippian formations of Chester age, although the lower formations do occupy considerable areas in Union and Hardin counties. The northwestern corner of this southern belt is separated from the central area by the valley of the Big Muddy River in Jackson County.

The main portion of this paper will be devoted to a discussion of the Upper Mississippian or Chester series, although the Lower Mississippian, or Iowa series as it may be called for want of any comprehensive name already in use, will be given some consideration in the discussion of the geological history.

The Iowa series was subdivided into a number of well-recognized formations more than half a century ago, mainly through the work of James Hall¹ in Iowa, although some attempt at subdivision had been made before Hall's time, and the subdivisions and classification has been somewhat elaborated in later years. In the main, however, the divisions established by Hall constitute the formations that are recognized at this time. Not so with the upper Mississippian. The early workers generally recognized in this series a more or less confused succession of limestones, shales, and sandstones, and but little attempt was made to subdivide the series. Hall gave the name Kaskaskia limestone to the whole of the succession above a conspicuous sandstone formation in the Mississippi

¹ *Report on the Geological Survey of Iowa* (1858).

River bluffs of Randolph County which was commonly called the "Ferruginous Sandstone." Worthen used the name Chester limestone for the same beds which Hall called Kaskaskia, but included this Chester limestone with the underlying sandstone in what he called the "Chester Group."

While both Hall and Worthen based their descriptions of the upper Mississippian rocks upon observations made for the most part in the second of the areas which have been mentioned, Henry Engelmann carried on field studies in the more southern counties of the state, under the direction of the Illinois Geological Survey. In Johnson, and in the counties to the east and west, Engelmann recognized an alternating succession of limestone and sandstone members of the Chester Group, ten in all, which he designated by the numbers 1 to 10, beginning the numbering at the top. The sandstones in the series received the even numbers and the limestone and shale members the odd numbers. The only one of these members to which a distinct name was given was No. 8, which was called the Cypress sandstone¹ from the good exposures in the bluffs of Cypress Creek, but even this name was abandoned in the later reports by Engelmann and was never used by Worthen.

The real importance of the Chester series in the Mississippian as a whole is well shown by its comparative thickness. The whole of the lower Mississippian or Iowa series has a thickness of approximately 1,000 feet, which was subdivided at an early time, as has been stated, into a succession of well-defined formations, but the Chester series, with a maximum thickness of more than 1,200 feet, commonly has been treated as a single formation by all geologists up to a very recent date.

The first serious attempt to subdivide the Chester was made by Ulrich² in 1905. He recognized four formations as follows: 4. Birds-ville formation; 3. Tribune limestone; 2. Cypress sandstone; 1. Ste. Genevieve limestone.

The observations which led to this division of the Chester into definite formations were inadequate for the proper understanding of the whole series, and mistakes of so serious a character were

¹ *Trans. St. Louis Acad. Sci.*, Vol. II, Part 1 (1863), p. 189.

² Prof. Paper, *U.S. Geol. Survey*, No. 36.

made that it has not been possible to adapt any part of the scheme to the more recent work on the series. In the first place the Ste. Genevieve limestone was mistakenly included in the Chester Group because of the failure to recognize that the upper member of this limestone as defined, the Ohara, was really made up of two very distinct parts, only the upper one of which is really Chester, and this "Upper Ohara" really has no place whatsoever in the Ste. Genevieve limestone when that formation is properly limited in accordance with its typical exposures in Ste. Genevieve County, Missouri. In the second place the sandstone designated as Cypress by Ulrich was not the Cypress of Engelmann, but the bed that was properly sandstone No. 10 of that author. In the third place, beds which really belong in three totally different positions in the Chester series were designated as Tribune limestone. The limestone at Tribune, Kentucky, which gave origin to the name, has more recently been shown to occupy a position far above that designated for the formation, and is in fact representative of a limestone member far up in the Birdsville formation as defined by Ulrich. At another locality the so-called Tribune is a limestone beneath the sandstone that was mistakenly called Cypress, while elsewhere it does occupy the position assigned to it in the definition of the formation, above the miscalled Cypress sandstone. In the fourth place the Birdsville formation of Ulrich comprises a succession of limestones, sandstones, and shales, and is as lacking in utility as a formation as was the older name, Chester formation.

The work upon which the present paper has been based has been carried on continuously under the auspices of the Illinois State Geological Survey, from 1911 to the present time, and was preceded by more general observations upon the Chester series since 1906. From 1911 to the present time the work of mapping in detail the Chester series in Illinois has been in progress, and it has now covered the counties of St. Clair, Monroe, Randolph, Jackson, Johnson, Pope, and Hardin. The only portion of the Chester belt across the state that has not been studied and mapped in detail at the present time is in Union County and a corner of Jackson, and reconnaissance observations in Union County have

shown that very little if anything new in the section can be looked for there.

In the course of these studies it has been found to be necessary and perfectly practicable to subdivide the Chester series into sixteen distinct formational units, which can be distinguished and mapped with ease. The limestones of the series, with one possible exception, are all continuous across the state, from their first appearance from beneath the Pennsylvanian strata in St. Clair, Monroe, or Randolph counties, on the northwest, to Hardin County at the extreme southeastern part of the belt. The sandstone formations, however, are not all continuous across the state; one has its greatest development in the west, thins out, and disappears to the east. Several of them have their great development in the east and become much thinner or disappear entirely in the more western portion of the state. The two uppermost sandstones of the series, however, are present uniformly across the state.

This entire series of Chester formations in Illinois may be arranged in three larger groups that possess rather distinct faunal characteristics, and these three divisions may be designated as lower, middle, and upper Chester. The names of these Chester formations, with their arrangement in the larger divisions are as follows:

Upper Chester Group:

16. Kinkaid limestone
15. Degonia sandstone
14. Clore limestone
13. Palestine sandstone
12. Menard limestone
11. Waltersburg sandstone
10. Vienna limestone
9. Tar Springs sandstone

Middle Chester, or Okaw Group:

8. Glen Dean limestone
7. Hardinsburg sandstone
6. Golconda limestone
5. Cypress sandstone

Lower Chester Group:

4. Paint Creek limestone
3. Yankeetown formation, and Bethel sandstone
2. Renault limestone
1. Aux Vases sandstone

In the naming of these units, those formations are designated as limestones which include notable limestone beds. In all cases such formations include a considerable amount of shale, in some

cases, locally at least, more shale than limestone, and some of them do include minor arenaceous layers. They are called limestones, however, because they are primarily calcareous as distinguished from the alternating sandstone formations. Each of these formations will be considered briefly, their leading lithologic and faunal characteristics will be pointed out, as well as their geographic distribution in the state, and in some cases their distribution beyond the limits of Illinois, in part at least. This will be followed by some statements concerning the geological history of the Illinois basin in Chester time, and its relations to the history of the preceding Iowa time.

LOWER CHESTER GROUP

Aux Vases sandstone.—The Aux Vases sandstone is typically exposed in the Mississippi River bluffs of Randolph County, Illinois, and Ste. Genevieve County, Missouri. It is the formation that was called “Ferruginous sandstone” by the early Mississippi valley geologists, the name Aux Vases being first used by Keyes in 1892,¹ from the exposures in Ste. Genevieve County, Missouri, near the mouth of River Aux Vases. It was the belief of Engelmann and also of Worthen that this basal sandstone in the Mississippi River section was the exact equivalent of sandstone No. 8, or Cypress sandstone of Engelmann’s Johnson County section. With such a correlation accepted, Keyes name would be synonymous with the earlier Cypress. In the assumption that the Aux Vases–Cypress correlation was correct, the name Aux Vases was abandoned in our earlier work in Illinois. It was early recognized, however, that there was a stratigraphic break within the arenaceous beds of the basal portion of the Chester series in Monroe and Randolph counties, and with the belief that the name Cypress covered all of these beds and that the Aux Vases was the exact equivalent of the Cypress, the name Brewerville² was used by the writer for that portion of the sandstone which lies beneath the break. Later, when studies in the more southern counties of Illinois established the fact that the Cypress and the old “Ferruginous sandstone” were not equivalent, and when studies

¹ *Bull. Geol. Soc. Amer.*, Vol. III, p. 296.

² *Trans. Ill. Acad. Sci.*, Vol. VI (1913), p. 121.

across the Mississippi River, in Missouri, showed that the typical section of the Aux Vases was the exact equivalent of the beds for which the name Brewerville had been used, the latter name was abandoned and the name Aux Vases adopted for the lowest sandstone formation of the Chester series in the Mississippi River section.

In its surface outcrop this formation is restricted to a belt through Monroe and Randolph counties, Illinois, continuing into Ste. Genevieve County, Missouri. The formation is a very massive, fine- or medium-textured sandstone in thick beds, in most places more or less conspicuously cross-bedded. Its color on freshly broken surfaces is a soft brown tint, in some localities becoming nearly white. Not infrequently it is mottled with small, dark-brown specks. On long-exposed weathered surfaces, the color in most localities is a darker brown than that of freshly broken surfaces. The massiveness of the formation is well shown in the Mississippi River bluffs between Prairie du Rocher and Modoc and in some of the picturesque gorges which have been eroded in the formation where it is crossed by stream valleys. No fossils of any sort have been found in the Aux Vases sandstone in Monroe or Randolph counties.

The unconformable relations of the Aux Vases sandstone upon the underlying Ste. Genevieve limestone are well shown in a number of places in Illinois. The uneven line separating the two formations can be clearly seen in the Mississippi River bluffs above Modoc. Elsewhere there is an important basal conglomerate in the Aux Vases, such conglomerates being well exposed two miles southeast of New Design, in S.E. $\frac{1}{4}$, S.W. $\frac{1}{4}$, Sec. 28, T. 3 S., R. 9 W., and again five miles southeast of Waterloo in the bluffs of Rock House Creek, in S.W. $\frac{1}{4}$, Sec. 4, T. 3 S., R. 9 W. Still another excellent exposure of the basal conglomerate, apparently resting upon the St. Louis limestone rather than the Ste. Genevieve, is about 6 miles west of Red Bud, in S.E. $\frac{1}{4}$, N.E. $\frac{1}{4}$, Sec. 4, T. 4 S., R. 9 W. A very excellent exposure of this same basal conglomerate is exposed in the Mississippi River bluffs just below McBride, Perry County, Missouri. The pebbles in these conglomerates are practically all chert, they are more or less angular for the most part,

and were clearly derived from the underlying Ste. Genevieve or St. Louis limestones.

The presence of these conglomerate beds establishes the fact that subsequent to the deposition of the Ste. Genevieve limestone, the calcareous sediments hardened into limestones, the cherts which are clearly secondary in origin were formed, and were in essentially the same condition in which they are found today. Then an erosion period set in and in places the entire thickness of the Ste. Genevieve limestone was removed, along with a part of the St. Louis limestone. The subsequent sedimentation laid down the sands of the Aux Vases formation. This interruption in the deposition of the sediments of the Mississippi Valley section must have represented a considerable length of time, and it must be reckoned as an important break in Mississippian history. Other phenomena connected with this sedimentary break will be discussed later, in connection with the geological history.

Beyond Monroe and Randolph counties, to the south, the Aux Vases sandstone has not been certainly identified. There is, however, a flaggy sandstone, about 20 feet thick, in the base of the Chester section east of Anna, in Union County, Illinois, which may be an extension of the Aux Vases, but in view of the fact that this sandstone contains numerous fossils in some beds, while the Aux Vases is quite barren of fossils, and further that sandstone beds are commonly present in the Renault formation of Monroe and Randolph counties, it is possible that this Union county sandstone may be younger than any part of the Aux Vases, and is perhaps referable to the Renault.

The maximum thickness of the Aux Vases sandstone is about 75 or 80 feet, and it varies from this amount to nothing at all, for in places the overlying Renault formation overlaps the Aux Vases and rests upon the underlying Ste. Genevieve limestone. In the more southern counties of Illinois, east from Union County, the position of the Aux Vases sandstone in the section is represented by an unconformity in the midst of the so-called "Ohara limestone member" of the Ste. Genevieve limestone, as described by Ulrich.

Renault limestone.—It would perhaps be better to call this unit the Renault formation, for in addition to its limestone content it

includes much shale and sandstone. It is, however, the first epoch of calcareous sedimentation in Chester time, and while locally there were considerable accumulations of clastic materials near the shore lines of the period, at a distance from the shore the material deposited was wholly limestone and calcareous shale. The name of the formation has been derived from Renault township, the southernmost township in Monroe County. The belt of outcrop of the formation crosses the whole of Monroe County in a north and south direction, and extends northward across the southwestern portion of St. Clair County and southward across the northwestern corner of Randolph County. The outcrops of this formation along Hickman Creek, in St. Clair County, are the most northerly exposures of any Chester formation. In a southerly direction the formation is exposed west of the Mississippi River across the southeastern corner of Ste. Genevieve County, Missouri, and continues for a short distance into Perry County.

Throughout the area of outcrop of the Renault in these Mississippi River counties, the formation is constituted of a very great variety of sediments, limestone, sandstone, and shale being represented, with each type of rock exhibiting great variation in its lithologic characters. In fact, one of the characteristics of the formation in this typical region, is its notable heterogeneity. This great variety in sedimentation is doubtless due to the beds having been laid down in proximity to the shore line of that time.

Beyond the Mississippi River counties, the Renault is known in Union County and from here it outcrops in a continuous belt, except where it is interrupted by faulting, across Illinois to Hardin County, and is also known across the Ohio River in Kentucky. In Union County the formation contains a considerable amount of clastic material in its lower part, perhaps including the flaggy sandstone east of Anna, which has already been mentioned as possibly representing the Aux Vases. Besides this sandstone and some overlying, variegated shales there is nearly or quite 100 feet of limestone referable to the Renault in the Union County section, and the limestone continues across the state, but not everywhere with this thickness. In the southeastern part of the state, especially in Hardin County, and also in Crittenden County, Kentucky,

there are some shaly beds at the base of or just beneath the Renault which have been called the Shetlerville formation, from Shetlerville, Hardin County, Illinois. These beds might perhaps be considered as a member of the Renault rather than as a distinct formation, but they are characterized by certain faunal elements that are somewhat different from the overlying Renault. There is some reason to believe that the Shetlerville beds are represented in the lower portion of what has been called Renault in Union County, but further detailed field work is necessary to establish such a conclusion. East of Union County all of the beds of the Renault or Renault-Shetlerville interval are limestones and more or less calcareous shales.

In the region of its typical development in Monroe County, Illinois, the Renault exhibits a maximum thickness of about 100 feet, but it varies from this maximum to a minimum of less than 20 feet, and doubtless actually thins out to nothing at all. The exposures of the formation in Ste. Genevieve County, Missouri, vary in thickness from about 46 feet to 75 feet or more, and there may be a maximum thickness of 100 feet in the county. In Union County there is 100 feet or more of Renault, but to the east of this county the formation in combination with the Shetlerville, is somewhat less than this, varying from 60 to 80 feet in most sections.

The Renault formation rests unconformably upon whatever lies beneath it, wherever it has been observed in Illinois and Missouri. In the Mississippi Valley counties it overlaps the Aux Vases sandstone and in many places rests upon the older Ste. Genevieve or even on the St. Louis limestone in places. The sub-Renault unconformity is well indicated by the presence of a basal conglomerate at a number of widely separated localities. The best exhibitions of this conglomerate are in St. Clair County, Illinois, on a tributary of Hickman Creek three miles northwest of Millstadt, and in Ste. Genevieve County, Missouri, about halfway between the mouth of Saline Creek and St. Marys. In both of these localities the underlying formation is the Aux Vases sandstone. The conglomerate is constituted of rounded pebbles of chert with an occasional pebble of igneous rock, ranging in size from two inches in diameter to a fraction of an inch. All through the southern counties of Illinois

the Renault-Shetlerville rests unconformably upon the Ste. Genevieve limestone, and this unconformity must represent a time interval not only equivalent to that between the Renault and Aux Vases in Monroe and Randolph counties, but a very much greater time during which the Aux Vases sandstone was deposited and also the time interval preceding the Aux Vases during which the underlying Ste. Genevieve and St. Louis limestones were solidified and their secondary chert formed, following which the whole of the Ste. Genevieve and a part of the St. Louis limestones were removed by erosion in some parts of the region. The unconformity represented by all of these events in Mississippian history must be considered as being of great importance in the classification of the Mississippian as a whole.

The limestones of the Renault are all more or less fossiliferous wherever they occur, and in some localities faunas of considerable magnitude can be secured. One of the forms which can be found with careful search, wherever good exposures of the Renault are present, is the crinoid *Talarocrinus*. This crinoid genus is represented by several species whose geographic distribution is somewhat different, but the same species is known to occur in localities as far apart as Monroe and Hardin counties. A peculiar feature of the genus is its two basal plates, and nearly all of the Renault species have the suture between the two plates somewhat impressed, giving to the base a distinctly bilobed form. These bases and the separated radial plates are the portions most commonly met with, and from these fragments the species cannot be certainly determined, but these bases alone seem to be sufficiently characteristic to be distinctive of the Lower Chester faunas, and they are much more commonly met with in the Renault than in the Paint Creek, the higher limestone unit of the Lower Chester. Another fossil form which is very characteristic of the Lower Chester beds, is the bryozoan *Cystodictya labiosa*, which occurs in both the Renault and the Paint Creek, but has nowhere been observed in any higher formation. The Renault fauna can be differentiated from that of the higher Paint Creek limestone, among other ways, by reason of the much less number of *Archimedes* and *Pentremites*, representatives of both of these genera being very conspicuous in the Paint

Creek while *Archimedes* especially, which is such an abundant form in most of the Chester faunas, is inconspicuous in the Renault in most localities, and in very many collections does not occur at all.

The basis for correlating the Renault across the entire state of Illinois, from St. Clair County to Hardin County, is not only the position of the formation in the stratigraphic column, but also the uniformity of the fossil faunas which occur in the formation. Every species which has been recognized in the Shetlerville-Renault faunas of the southern counties, with the exception of four which are wholly restricted, so far as known, to the Shetlerville beds of Pope and Hardin counties, are known to be present in the typical Renault of Monroe County, except one form which is known in the Paint Creek. Furthermore, the especial index fossils of the Ste. Genevieve limestone have nowhere been found in association with the Renault-Shetlerville fauna. While it is not possible in this place to enter into a discussion of the details of the faunal characters of the horizon, it can be said that most detailed studies of these Lower Chester faunas seem to establish without any doubt the paleontological correlation of the Renault horizon across the entire state.

The sandstone beds of the Renault are commonly less massive than those of the Aux Vases, and they not infrequently contain the fossil trunks of a species of *Lepidodendron*, while no fossils at all have been observed in the Aux Vases.

*Yankeetown chert*¹ and *Bethel sandstone*.²—Succeeding the Renault formation in the Monroe-Randolph County area in Illinois, there is a thin, but very peculiar and persistent bed, which has been called the Yankeetown chert. This formation is siliceous throughout, much of it is a true chert, but in many localities it is seen to include numerous sand grains and locally it is a quartzite. The bedding of the formation is exceedingly irregular and knotty in many places, but locally at least it is quite even. In many places the rock exhibits a distinct, horizontally banded appearance, the separate bands being slightly different in color and only a small fraction of an inch in width. As ordinarily seen in surface outcrops

¹ Weller, *Trans. Ill. Acad. Sci.*, Vol. VI (1914), p. 124; also *Ill. State Geol. Surv.*, Monog. I (1914), p. 25.

² Butts, *Mississippian Formations of Western Kentucky* (1917), p. 63.

the Yankeetown is rather light colored, and it may be detected in many places by the presence of the fragments of nearly white chert scattered through the surficial deposits.

The thickness of the Yankeetown in the Mississippi River counties nowhere exceeds 20 feet, and in places it is perhaps less than 10 feet thick. In spite of its thinness, however, the Yankeetown is very persistent, and is uniform in its characters from a point in St. Clair County not more than eight or nine miles south of East St. Louis, to near Lithium in the northern part of Perry County, Missouri.

Where the Lower Chester formations reappear in Union County, Illinois, the horizon of the Yankeetown is occupied by a sandstone formation quite different in character from the Yankeetown, which has been named the Bethel sandstone by Butts from outcrops in Kentucky. This sandstone holds its position in the Chester section from Union County to Hardin County, except where the outcropping belt is interrupted by faulting, although in southern Johnson County there is a short interval where the formation is entirely lacking. In the first section in Union County, east of Anna, where the Bethel sandstone has been observed, its thickness is comparable to that of the Yankeetown in Monroe and Randolph counties. It is certainly not greater than 20 feet, and perhaps does not exceed 10 feet. Traced to the eastward across the southern counties to the eastern edge of Johnson County, the Bethel nowhere exhibits a thickness greater than 25 or 30 feet, and at one locality at least, in Johnson County, it is lacking altogether. In western Pope County the formation is interrupted by a great, down-dropped fault block, and where it is exposed to the east of this fault block it is considerably thicker, and continues to increase to the east, attaining a thickness of at least 100 feet in southwestern Hardin County.

This sandstone continues southward across the Ohio River into Kentucky, and it is this formation which Ulrich mistakenly considered to be the equivalent of the Cypress sandstone of Englemann, an error which he has acknowledged and corrected in his latest contribution to the subject.¹

¹ *Formations of Chester Series in Western Kentucky* (1917), p. 8.

Wherever the contact of the Bethel sandstone with the underlying Renault is exposed, there is evidence of unconformity between the two formations. In the Ohio River bluffs in southeastern Hardin County this contact is well exposed, the lower layer of the sandstone, 6 to 18 inches in thickness, is composed of fragmental material consisting of flat pebbles, slabs more or less irregularly disposed, much lime sand, quartz sand of large, rounded grains, with many fragments of fossils, some of which are worn and rounded. The actual line of contact between the two formations is uneven and undulating. At Indian Point, in southern Johnson County, the basal layer of the Bethel sandstone is a lime conglomerate with more or less flattened pebbles up to two or three inches in maximum dimension. The unconformity of the Yankeetown upon the underlying Renault in the Mississippi River counties, is suggested by the varying thickness of the Renault, and by the uniform character of the Yankeetown, resting in different places upon limestone, shale, and sandstone layers of the Renault.

The correlation of the Yankeetown-Bethel horizon entirely across the state must be based upon the correlation of the underlying and overlying formations, both of which are abundantly fossiliferous. No determinable fossils have anywhere been collected from the Yankeetown, and the invertebrates that have been found in the Bethel are a few very imperfect examples of common Chester types of brachiopods and bryozoans. This sandstone does contain, in places, numerous fragmentary plant remains, mostly tree trunks, of which the only form that can be identified is *Lepidodendron*, probably of the same type that was present in the sandstone layers of the Renault, and which is present in most of the Chester sandstones.

*Paint Creek limestone.*¹—Overlying the Yankeetown and Bethel formations is the Paint Creek limestone and shale. In the Mississippi River counties, extending from St. Clair County, Illinois, to Perry County, Missouri, there is present in the lower part of this formation, a persistent bed of deep-red, non-laminated clay or shale, 12 to 15 feet in thickness. Between this red clay and the

¹ Weller, *Trans. Ill. Acad. Sci.*, Vol. VI (1914), p. 125; also *Ill. State Geol. Surv.*, Monog. I (1914), p. 26.

Yankeetown for a thickness of about 10 feet there is a series of bluish, calcareous shales with platy limestone layers, and above the red bed there are other calcareous shales which pass up into limestones, thinly bedded and shaly below, becoming more massive above, these beds being succeeded by more shale beds some of which are variegated red and blue in color. Although there are other reddish or at least variegated shale beds elsewhere in the Chester section, there is no bed anywhere in the series in Illinois that can be mistaken for the deep-red clay bed of the lower part of the Paint Creek formation. Not only is this bed recognizable in surface outcrops, but it can be easily detected in many well records.

The red shale bed of the Paint Creek formation outcrops at intervals throughout the Chester belt from St. Clair to Randolph counties, the northernmost exposure being about one mile northwest of Millstadt. The formation continues across the Mississippi River into Missouri, and the southernmost exposure is in northern Perry County of that state. Between these two localities the same red shale bed is exposed at many localities. It is exceedingly uniform in its characteristics, and where it is met with it is absolutely impossible to mistake it for any other bed in the Chester series.

The limestones of the Paint Creek formation are similar in lithologic character to many other limestones of the Chester series. The several beds are separated by shale layers varying in thickness from an inch or so to several feet, and the limestone beds themselves vary in thickness from less than one foot to three or four feet. Most of the shale beds are more or less calcareous, but above the main mass of limestone there is a considerable body of shale in many sections that is little or not at all calcareous, and is variegated red and blue or purple. Most of the limestone beds are crystalline, some are quite pure and white, others are more impure and much darker in color.

In the southern counties of the state, from Union to Hardin, the Paint Creek is represented mostly by shales, with only subordinate limestone layers, commonly very thin and exhibiting considerable variation in the entire amount that is present. The deep-red shale bed is wanting in the section in these southern

counties, but the shales that are present commonly weather into a red, residual clay which somewhat resembles the material in the red bed of the Mississippi River section. When not weathered, the Paint Creek shale of the southern counties is very fissile, breaking into thin, brittle flakes which are slightly olive green in color when dry, but appear quite black where the exposures are in situations where the rocks are kept constantly wet. In one locality in Johnson County a bed of somewhat variegated red and blue shale has been observed similar in character to some of the beds in Monroe County.

The limestone layers included in the Paint Creek formation in the southern counties vary greatly in character. In places some of these layers are very siliceous, some of them being little more than layers of sand firmly cemented with calcium carbonate, other layers are hard, dense, and compact with few or no sand grains, still other beds are quite free from silica, and some of them, at least, are more or less coarsely crystalline, dark limestone, quite like some of the beds in the more typical exposures of the formation in Monroe County.

The fauna of the Paint Creek is uniform in its essential features, through the full extent of the formation in Illinois. It has much in common with the faunas of the Renault, and the two formations together constitute the two fossiliferous horizons of the Lower Chester. The bryozoan *Cystodictya labiosa* is common in both horizons, as are the species of *Talarocrinus* with bilobed bases, but the Paint Creek fauna includes a much greater number, both of individuals and species, of *Pentremites*, and the bryozoan genus *Archimedes* is far more abundant than in the Renault. The same species of *Pentremites* are present in the fauna from St. Clair to Hardin counties.

The Paint Creek occupies the position in the section which was originally assigned to the Tribune limestone by Ulrich, though it is by no means the equivalent of the formation so named, at Tribune, Kentucky. More recently Butts¹ has proposed to substitute the name Gasper for Tribune, because of the unfortunate choice of

¹ Butts, *Mississippian Formations of Western Kentucky* (1917), p. 64.

that name for the formation by Ulrich. The Paint Creek is the equivalent of the higher portion, at least, of the Gasper limestone of Kentucky.

MIDDLE CHESTER GROUP

In passing from the Lower to the Middle Chester formations, the region of typical and more complete development is found to be in the more southern counties of Illinois, rather than in the Mississippi River counties. As in the case of the Lower Chester, the Middle Chester is constituted of four formations, two siliceous and two calcareous.

Cypress sandstone.—This is the formation for which Engelmann chose the name Cypress sandstone, from the exposures in the bluffs of Cypress Creek, Union County, but it is not the sandstone for which Ulrich used the same name in the report on "The Lead Zinc and Fluorspar Deposits of Western Kentucky."¹ The formation is continuously present in the Chester section from Hardin County at the east to Union County at the western extremity of the southern belt of outcrop of the formations. It is a very massive, cliff-forming sandstone, and except where it is interrupted by faulting in Hardin, Pope, and Johnson counties, it forms the upper portion of a nearly continuous escarpment across the state which is a conspicuous topographical feature. The formation is more uniform in its character throughout its extent in these counties than any other sandstone formation in the Chester series. Some other sandstones are just as massive and make just as conspicuous cliffs in places, but they do not retain such a character throughout for the reason that the massive portions of the other sandstones are much more interrupted, both vertically and horizontally, by thinly bedded and less resistant layers.

The lithologic character of the Cypress is similar to other sandstones of the series, or at least to certain portions of most of the other sandstones. It is rather fine in texture, yellowish brown in color, with more or less cross-bedding, although certain portions of the formation are conspicuously even-bedded, and in places, especially in the upper portion of the formation, the even beds

¹ Prof. Paper, *U.S. Geol. Surv.*, No. 36 (1905).

suggest the regular courses in a well-built masonry wall. The weathered surfaces of the cliffs become darker colored than the freshly broken rock, and in places more or less iron stained. The fossils of the Cypress sandstone consist of more or less fragmentary plant remains, the only recognizable form being *Lepidodendron* trunks.

It has not been possible to measure the exact thickness of the Cypress sandstone in any section in the southern counties of the state. The base of the formation, resting upon the Paint Creek shale, can be approximately determined in many places, but the top of the section in these same sections is in all cases missing and the upper portion has been more or less reduced by weathering. The greatest actual thickness that has been observed in a cliff is about 70 feet, but the thickness has been estimated as 110 feet in at least one section, and the average thickness across these counties is about 100 feet.

In tracing the stratigraphic position of the Cypress sandstone into the section of the Chester series of the Mississippi River counties, the sandstone is found to be much reduced in thickness and much less massive in character. In this section, as originally described by the writer,¹ a sand and shale formation overlying the Paint Creek limestone was named the Ruma formation. The later study of the section in the more southern counties has shown that the sandstone of the Ruma should be considered as the thinned-out margin of the Cypress sandstone, and that the shales below should more properly be considered as being a part of the Paint Creek. With this interpretation the name Ruma becomes superfluous, and Cypress may be extended to include these sandstone beds of the Ruma in Monroe and Randolph counties. In following the section still farther, into Missouri, it is found that the Cypress sandstone disappears entirely, and the super-Cypress limestones rest directly upon the Paint Creek.

In a recent contribution Ulrich² has proposed the correlation of the Cypress sandstone of the southern counties with the Lower

¹ Weller, *Trans. Ill. Acad. Sci.*, Vol. VI (1914), p. 126; also *Ill. State Geol. Surv.*, Monog. I (1914), p. 26.

² "The Formations of the Chester Series in Western Kentucky, and Their Correlates Elsewhere," *Ky. Geol. Surv.*, Plate D, opposite p. 47.

Okaw limestone of Monroe and Randolph counties. Such a correlation, however, is not supported by the evidence of the fossils and the faunal studies of the Chester have established beyond question the exact equivalence of the Golconda limestone of the southern counties with the Lower Okaw in Randolph County.

Golconda limestone.—When the Chester section in the Mississippi River counties was first elaborated by the writer, the name Okaw limestone was given to a thick series of limestones with shale partings overlying the so-called "Ruma" formation. It was recognized that this was probably a composite formation, and an attempt was made to map the higher beds as a separate unit from the lower ones, but this was finally abandoned because the heavy covering of drift seemed to make such a procedure impracticable. When the studies were carried into the more southern counties, it developed that the limestone beds equivalent to the Okaw were divided into two distinct units separated by an important sandstone formation. The lower of these two units has been named Golconda limestone from the excellent exposures in the Ohio River bluffs just above Golconda, in Pope County.

The Golconda limestone is constituted of a succession of limestone and shale beds, the details of which are commonly obscured by surficial material, and it is not known whether the details of the succession of beds are uniform throughout the areal extent of the formation. The limestone beds vary considerably in character, but in general they are of a light- or dark-gray color, and more or less crystalline in texture, with some layers oölitic. The shales are fully as variable and perhaps more variable than the limestones. Some of them are highly calcareous, while others are quite purely argillaceous; many of the beds are gray or buff, but others are dark and even black, and at a number of localities a layer of reddish shale has been observed. In the basal part of the formation there are shale beds with a considerable content of sand, and even some thin sandstone layers, but beds of this character are not present higher up in the formation.

In tracing the Golconda limestone into the Mississippi River counties, where it is represented by the lower and main portion of

the Okaw limestone, the characteristics of the formation remain much the same, although the local details are different. As in the southern counties there is a succession of limestone and shale members, but there is a larger content of limestone in the more western region. The limestone beds themselves are crystalline in texture, like those in the south, they vary in color from essentially white to dark gray, the lighter colors on the whole being more dominant in Monroe and Randolph counties, and the oölitic beds being much more conspicuous. The shale beds are similar in the two regions.

The establishment of the continuity and equivalence of the Golconda and the lower portion of the Okaw is based not alone upon their occupying an equivalent position in the section, but upon the paleontological characters as well. One of the notable horizon markers of this lowest limestone formation of the Middle Chester is the little brachiopod *Camarophoria explanata*. This species is unknown in the Lower Chester faunas, but is a common member of all the Middle Chester faunas, and is present, abundantly in places, in some of the Upper Chester formations. The horizon where it is first introduced in the section can be considered as being well toward the base of the Golconda limestone. In the southeastern counties of the state one of the most reliable guide fossils for the lower Golconda is the Crinoid *Pterotocrinus capitalis*, which is commonly represented by the "wing-plates" alone. This species has not been recognized in Randolph or the adjoining counties, but in this region the near basal beds of the lower Okaw are characterized by the presence of a peculiar and very unusual fauna, for the Chester series at least, composed very largely of small pelecypods and gastropods, including many Bellerophontids. Many of the species of this fauna are undescribed, and some of them are peculiar and extraordinary. In southern Johnson County, at one locality, a fauna has been collected from near the base of the Golconda, in which most of these peculiar basal Okaw species are present, and associated with them are many examples of the characteristic *Pterotocrinus capitalis*. This mingling of forms, so peculiar in character, is assumed to be sufficient evidence to establish the equivalent of the Golconda with the lower Okaw, and the

name Golconda may be extended to include the equivalent beds in Randolph and Monroe counties.

The lithologic character of the Golconda limestone is of such a nature that its contacts with the underlying and overlying formations are not commonly exhibited, and at no locality have both of the contacts been observed in the same section. This condition makes the determination of the thickness of the formation a matter of estimate. In the neighborhood of Golconda the interval between the top of the Cypress sandstone and the base of the Hardinsburg is about 150 feet, and as this is the interval occupied by the Golconda, an approximate thickness of 150 feet may be assumed for the formation. The thickness of the whole of the Okaw limestone in the Mississippi River counties is something over 200 feet, and of this total thickness the lower Okaw, which is the equivalent of the Golconda, includes approximately 150 feet, being about equal to the Golconda in its typical exposures.

Hardinsburg sandstone.—Overlying the Golconda limestone and resting upon it unconformably is an important sandstone formation which in many places is scarcely less massive than the Cypress. Butts has given the name Hardinsburg¹ to this formation from a Kentucky locality. In general appearance, texture, color, etc., the Hardinsburg closely resembles the Cypress, and in isolated outcrops not seen in relation to an underlying or overlying limestone, it would not be possible in many places to differentiate the two formations. The Hardinsburg, however, is somewhat less massive on the whole, and includes considerable amounts of more thinly bedded sandstones in places. In general the Hardinsburg is somewhat thinner than the Cypress, although it does have a maximum thickness of at least 100 feet. There are places, however, in the southern counties where the thickness does not exceed 30 feet, and the average thickness is probably about 60 or 70 feet.

In the Mississippi River counties there is no conspicuous sandstone formation which corresponds in position with the Hardinsburg in the southern counties. There is present, however, within the formation to which the name Okaw was originally given, a horizon marked by a discontinuous sandstone layer which in

¹ *Miss. Form. W. Ky.* (1917), p. 96.

places is as much as 10 feet thick, elsewhere being wanting altogether. This layer is best exhibited in the vicinity of Chester, in the outside prison quarry at Menard, between Menard and Chester, and just below Cole's mill in Chester. This sandy layer in the Okaw is undoubtedly the attenuated margin of the Hardinsburg sandstone which has its greatest thickness in the southeastern part of the state, for the limestone beds above it possess many faunal characters which unite them with the limestone formation overlying the Hardinsburg in the southern counties.

Glen Dean limestone.—The Glen Dean limestone is another formation that has been named by Butts from exposures in Kentucky.¹ In the southern counties of Illinois the formation resembles the Golconda in general character, being composed of interbedded limestone and shale layers, but in most localities the proportional amount of shale is much greater in the Glen Dean, in places nearly the whole of the formation being shale. Many of the limestone beds in the formation are similar lithologically to those of the Golconda, being gray in color and crystalline in texture for the most part, but locally certain of the layers are somewhat more dense and compact.

The Glen Dean has certain faunal characters that differentiate it rather sharply from the Golconda. One of the best index fossils is a species of bryozoan, *Prismopora serrulata*. Examples of this species are triangular in cross-section, with three faces bearing zoöecia, these prismatic zoaria dividing at intervals. This bryozoan is not entirely confined to the Glen Dean, for it has been observed rarely in the Golconda, and is not uncommon in the Vienna limestone, still higher than the Glen Dean, but it is far more common in the Glen Dean than elsewhere, and in places some of the limestone ledges of this formation are veritable *Prismopora* gardens. *Pentremites spicatus* is another characteristic form, which has not been observed outside of this formation, but it is far less common than the *Prismopora*. A number of other bryozoans and some other fossil forms are more or less conspicuous in this formation, which are nearly everywhere or entirely unknown from other Chester horizons.

¹ *Miss. Form. W. Ky.* (1917), p. 97.

In the Mississippi River counties the whole assemblage of fossil forms which characterize the Glen Dean formation in the southern counties has been found to be present in those beds of the Okaw limestone which overlie the interrupted sandstone horizon in the midst of that formation, and these upper Okaw beds may be correlated directly with the Glen Dean and this name may be extended to include these beds in the Randolph-Monroe County section.

The thickness of the Glen Dean in the southern counties exhibits some variation from a minimum of 40 feet to a maximum of perhaps 75 feet. In the thinner sections it is apparently the higher beds that are missing, due perhaps, to the erosion of the upper surface of the formation before the deposition of the overlying sandstone. The thickness of the equivalent beds in Randolph County is similar to that in the southern counties, the usual thickness commonly being about 60 feet.

[To be continued]